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The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

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13. ABSTRACT (Maximum 200 words)

Under the support of this funding, UCLA are able to setup a complete high quality microwave power measurement system. Currently, this is the only system available in UCLA to perform on wafer automatic load pull measurement. Measurable frequency covers from 4GHz to 18GHz, driven power up to 20 Watts. By adding the noise equipment and sharing some equipment in this system, the system can perform low noise measurement. About ten technique papers have been published relating to this system so far.

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Final report to DDAAD 19-00-1-0114 40054-EL Nonlinear Microwave Power and Noise measurement and Analysis facility

Abstract: under the support of this funding, UCLA are able to setup a complete high quality microwave power measurement system. Currently, this is the only system available in UCLA to perform on wafer automatic load pull measurement. Measurable frequency covers from 4GHz to 18GHz, driven power up to 20 Watts. By adding the noise equipment and sharing some equipment in this system, the system can perform low noise measurement. About ten technique papers have been published relating to this system so far.

After carefully calibration, the facility is capable of measuring microwave devices with a frequency ranging from 6 GHz to 18GHz. Power up to 100 watts (for 7db gain device). Load pulling is automatic, computer controlled. Wafer chuck temperature controlled by a high efficiency heating exchanger, which can increase the temperature from 0C to 200C in seconds, and vise versa. This system facilitates BMDO GAMPA project research. System picture and some measurement results are attached as Fig1 to Fig. 5.

A complete System list:

Loadpull system:	
1. HP83640B swept signal generator (10MHz –40GHz)	$53,743.96
2. LogiMetrics Amplifier: (6GHz to 18GHz, 20Watts)	$15,978.78
3. Maury automatic tuner system: 0.8GHz – 18GHz)	
4. HP8722ES vector spectrum analyzer (50MHz – 40GHz)	$76,622.60
5. HP E4419B microwave power meter (50Mhz – 50GHz)	$7,301.46
6. HP6654A system DC power supply (9A, 60V)	$2,598.00
7. HP6653A system DC power supply (18A, 35V)	$2,598.00
8. Karl Suss probe station: PA200 (8")	$86,600.00
9. TRIO-TECH TC1000 temperature controller and recirculation system	
Noise measurement system:	
1. HP8970B noise figure meter	$52,652.80
2. HP8971C noise figure test set	
3. HP83711B (1-20GHz) synthesized CW generator	
Supplies:	$9,501.60
TOTAL	$307,597.20

Please be noticed that two items listed about, Maury automatic tuner system: 0.8GHz – 18GHz) and HP83711B (1-20GHz) synthesized CW generator were purchased under another funding in order to complete this system, which cost another roughly $120,000.

Published publications related to this facility are listed below:

1) S.Y.Lee, B.A.Cetiner, H.Torpi, S.J.Cai, J.Li, K.Alt, Y.L. Chen, C.P. Wen, K.L. Wang, and T.Itoh "An X-Band GaN HEMT Power Amplifier Design Using an Artificial Neural Network Modeling Technique" IEEE Trans. Electron Devices, March 2001, Vol. 48 No.3. pp495-502.
2) Li, J.; Cai, S.J.; Pan, G.Z.; Chen, Y.L.; Wen, C.P.; Wang, K.L. **High breakdown voltage GaN HFET with field plate.** Electronics Letters, vol.37, (no.3), IEE, 1 Feb. 2001. p.196-7. 6 references.
3) S.J. Cai, Y.S. Tang, R. Li, Y.Y. Wei and K.L. Wang "Annealing Behavior of A Proton Irradiated AlGaN/GaN HEMT Grown by MBE" ***IEEE Trans. Electron Devices***. Feb. 2000, vol. 47, No.2, pp304-308
4) S.J. Cai, Jiang Li, Y. L. Chen, Sang Lee, C.P. Wen and K. L. Wang " X-band AlGaN/GaN HEMT mini-module with 8W output" ***IEEE Topical Workshop on Power Amplifiers for Wireless Communications***". Sept. 11-12, 2000 San Diego, pp77-78
5) S. Y. Lee, B. A. Cetiner, S. J. Cai, J. Li, K. Alt, Y. L. Chen, C. P. Wen, K. L. Wang, and T. Itoh "An X-band GaN HEMT Power Amplifier Design Using an Artificial Neural Network Modeling Technique" ***IEEE Topical Workshop on Power Amplifiers for Wireless Communications***". Sept. 11-12, 2000 San Diego ,pp 60-62
6) R. Li, S.J. Cai, L. Wong, Y. Chen, K.L. Wang etc "An AlGaN/GaN Undoped Channel Heterostructure Field Effect Transistor with Fmax of 107 GHz" ***IEEE Electron Devices letter***. July 1999 vol.20 No.7 pp323-6
7) S.J. Cai, R. Li, Y.L. Chen, L. Wong, W.G. Wu, S.G. Thomas and K.L. Wang "High Performance AlGaN/GaN HEMT with Improved Ohmic Contacts" ***IEE Electronics Letters*** 26th November 1998 Vol.34 No.24 pp2354-6
8) Balandin, A.; Morozov, S.; Cai, S.J.; Li, R.; Li, J.; Wang, K.L.; Viswanathan, C.R.; Dubrovskii, Yu. Effect of channel doping on the low-frequency noise in GaN/AlGaN heterostructure field-effect transistors. ***Applied Physics Letters***, vol.75, (no.14), AIP, 4 Oct. 1999. p.2064-6. 10 references.
9) A. Balandin, S. Morozov, S. Cai, R. Li, K. L. Wang, G. Wijeratne, and C.R. Viswanathan, "Low Flicker-Noise GaN/AlGaN Heterostructure Field Transistors for Microwave Communications" ***IEEE Trans. on Microwave Theory and Techniques***, August 1999 Vol. 47, no.8 pp1413-8
10) A. Balandin, S.J. Cai, R. Li, K.L. Wang, V.R. Rao and C.R. Viswanathan "Flicker Noise in GaN/AlGaN N Doped Channel Heterostructure Field Effect Transistors" ***IEEE Electron Device Letters***, December. 1998 Vol.19 No.12 pp475-8

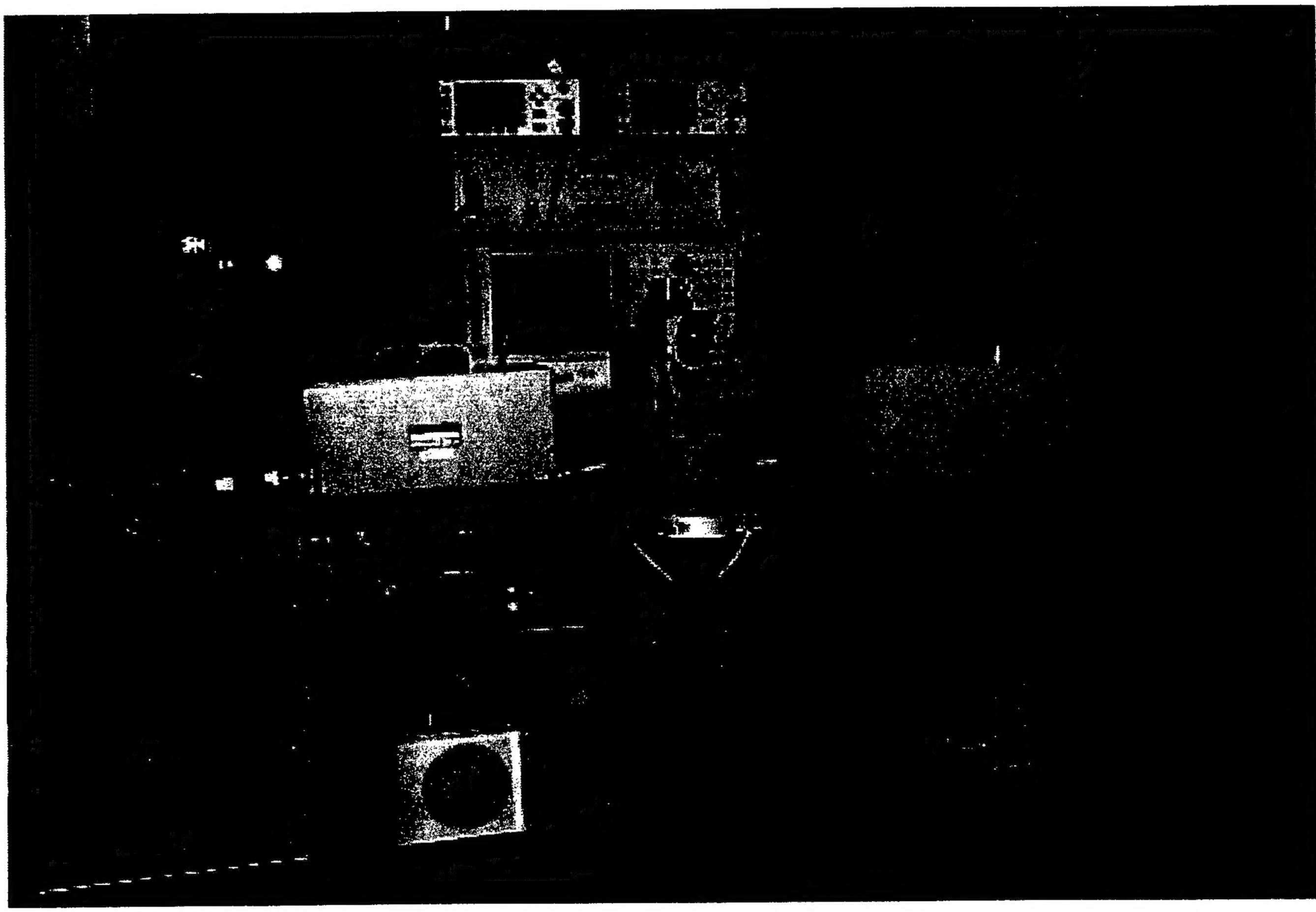

Fig1. Picture of the Nonlinear Microwave Power and Noise measurement system: Chuck temperature controlling range: 0C to 200C. Auto tuning frequency range up to 18 GHz, limited by Maury automatic tuner. Vector spectrum analyzer frequency ranges from 50Mhz to 40 GHz. Input power can be up to 20 Watts from 5 GHz to 18 GHz. Noise equipment are not shown above. Whole system is put on a N2 pressure gas floating optical table for vibration protection

Measurement results examples:

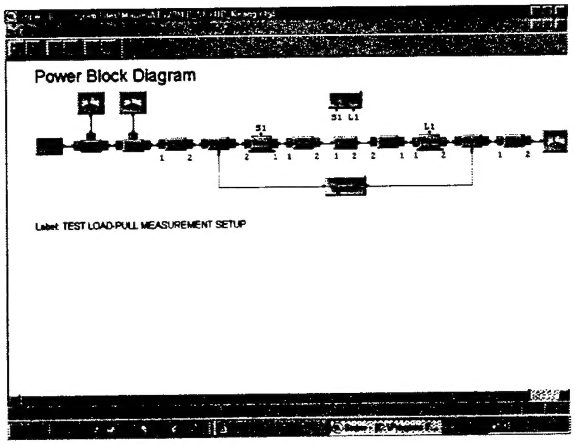

Fig2. Microwave nonlinear power measurement system

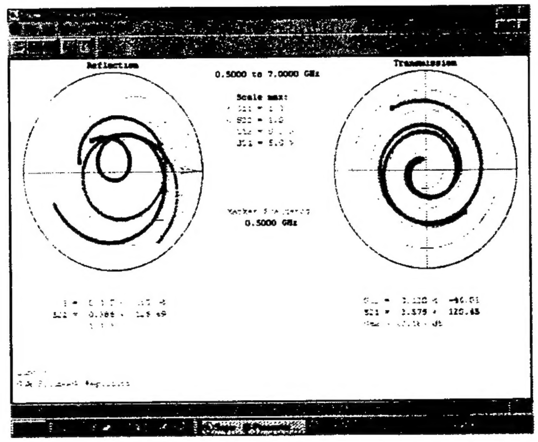

Fig 3. Source and Load S parameters change as frequency sweeping

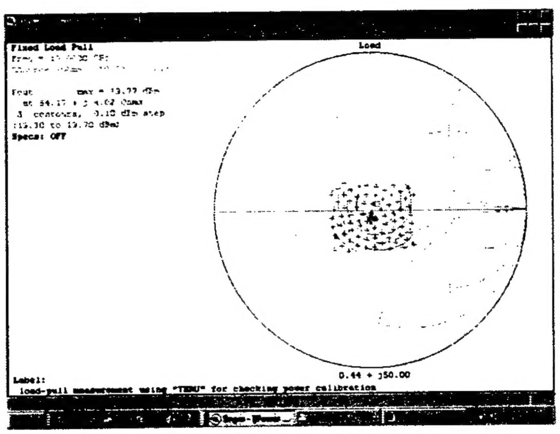

Fig4. load pull results to search for optimum loading point to get maximum output power

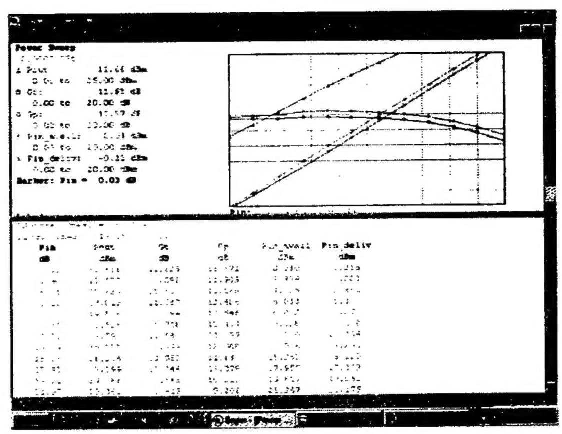

Fig5. Power sweep after source and load pull. Gain, efficiency and other interested parameters are also plotted